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MATHEMATICS ACHIEVEMENT, CAREER ASPIRATIONS, AND PERCEIVED IMPORTANCE OF MATHEMATICS: A CAUSAL MODELING APPROACH

BY

JESSE CHAN

A THESIS

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August 1, 2003

University of Alberta

Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled Mathematics achievement, career aspirations, and perceived relevance of mathematics: A causal modeling approach submitted by Jesse Chan in partial fulfillment of the requirements of the degree of Master of Education

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ABSTRACT

The present study used structural equation modeling to investigate the causal priority between mathematics achievement, career aspirations, and perceived importance of mathematics among high school students. It used longitudinal data from the Longitudinal Study of Mathematics Participation (n = 1518). Mathematics achievement was measured with the Canadian Achievement Tests mathematics achievement subtest. Career aspirations and perceived importance were based on responses on a student survey. Structural models were created for each pair of variables: mathematics achievement and career aspirations, mathematics achievement and perceived importance, and career aspirations and perceived importance. Separate models were created for males and females, as well as for the overall sample. It was found that causal predominance varied by gender and by grade level. In general, mathematics achievement appears to have causal predominance over career aspirations and perceived importance. Implications are discussed.

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CHAPTER 1: STATEMENT OF THE PROBLEM

Mathematics is the one subject that is most frequently identified as least favourite among high school students (McLeod, 1992). It is also a barrier to students' success in high school, and admission into post-secondary education. Meanwhile, the information technology revolution presents increasing demand for a mathematically literate workforce. Sells (1973, as cited in Jensen, 1997) called mathematics a critical filter for 70% of career choices at the university level—not only the hard sciences, but rapidly expanding areas such as health care, commerce, and computing sciences. This incongruity between students' disdain for mathematics and society's growing demand for mathematical competency presents a problem both for students, in seeking employment, and for society as a whole, in meeting the need for socioeconomic progress.

There has been much research showing the relationships between mathematics achievement, attitudes toward mathematics, and career choices. Much of it (e.g., King, 1995; Pricken, 1989) has been based on Hackett and Betz's (1981) application of Bandura's *self-efficacy* theory. It is theorized that *career self-efficacy* comprises an important factor in career choices, and that one's sense of self-efficacy is informed in part by prior achievement. This would account for the relationship between mathematics achievement and career aspirations, because students who have been successful in mathematics are more likely to see themselves in professional or technical positions requiring post-secondary education in the future. Thus, it is held that achievement affects career aspirations through the mediating variable of *mathematics self-efficacy*. An alternative line of research to the self-efficacy theory is the *task value* theory, which considers the role of career aspirations as a motivator for mathematics achievement. This

position assumes that when a student has a particular career path or goal in mind, he or she is motivated to a greater or lesser degree to succeed in mathematics in order to achieve that path or goal. Meece, Eccles Parsons, Kaczala, Goff, and Futterman (1982) called this task value. In this formulation, it is believed that career aspirations influence mathematics achievement through the mechanism of motivation.

Attitudes toward mathematics comprise several dimensions such as mathematics anxiety and liking of mathematics. In the present study, the aspect under consideration is *perceived importance,* the degree to which the student regards the material as important. How important a student considers mathematics to be is likely a function of what purpose the student anticipates that mathematics will serve for him or her. Probably, this would be primarily with respect to his or her career goals or further education. Specifically, a student who wishes to pursue considerable post-secondary training for a professional or technical career is likely to perceive mathematics as more important than one who does not. Thus, one's career aspirations could determine what one deems important, and this in turn could affect effort and ultimately achievement.

Perceived importance also may have an impact on achievement. Students who regard math as important are likely to be more motivated to invest effort in their mathematics studies, resulting in greater achievement. If a student believes that learning the material is instrumental to his or her goals, and not merely a necessary course requirement or prerequisite, he or she is likely to perceive mathematics as important. Thus, students' perception of the importance of mathematics can mediate the relationship between career aspirations and achievement. On the other hand, achievement may have an effect on perceived importance. It is possible that students with lower achievement in

mathematics may experience dissonance, which they resolve by deciding that mathematics is not, after all, so important.

Gender Differences

Research in the 1970's and 1980's found that males at the high-school level and beyond scored higher than females on tests of mathematics achievement (Jensen, 1997). It has been argued that this gender gap in achievement has been the result of females' choice not to pursue higher mathematical studies. This is consistent with findings that relatively fewer females entered mathematics-related occupations in the past (Kreger, 1988), and are less likely to perceive mathematics as useful (Betz & Hackett, 1983).

While the gender gap in mathematics participation and achievement appears to have been narrowing, gender differences still occur in higher level mathematics courses at the high-school level (eg. AAUWEF, 1992). Given the finding that low participation by females underlies the achievement gap, research has begun to shift toward exploring gender differences in attitude toward mathematics as a potential factor leading to gender differences in participation. Jensen (1997) also found that although females had less positive attitudes toward mathematics, they aspired to mathematics-related careers in numbers equal to males. This raises the possibility that gender could moderate relationships between achievement, attitudes, and career aspirations.

Purpose of the Study

Few studies have sought to determine the direction of causality between these three variables, and the actual causal direction remains ambiguous. For instance, is a student's performance in mathematics determined by his or her career aspirations, or is the reverse more likely to be true? Studies that address the direction of causality through

causal modeling are generally more difficult to do because they require the use of longitudinal data, as well as more elaborate statistical models. Using a large sample of high school students, longitudinal data, and structural equation modeling, the present study considered the following questions:

1. What is the causal ordering between mathematics achievement and career aspirations? That is, does achievement appear to precede and affect career aspirations, or do career aspirations affect achievement?

2. What is the causal ordering between mathematics achievement and students' perceived importance of the material?

3. What is the causal ordering between perceived importance and career aspirations?

4. Do gender differences exist in the causal ordering of these variables?

Definition of Terms

Causal modeling is a research paradigm that applies particular statistical techniques to longitudinal data to make inferences regarding the direction of causality. One such technique is structural equation modeling (SEM). This technique was used in the present study, since it permits stronger statistical inferences than alternatives such as path analysis (Bollen, 1989).

Perceived importance is the degree to which students consider mathematics course material to be "important" or "useful". For the purposes of the present study, it was based on students' responses to survey items asking about the importance of several mathematics topics and skills.

The term *career aspirations* is distinct from career choices because it refers to a student's self-report of his or her ambitions or goals rather than actual behaviours, and this aspiration may or may not correspond to eventual career choices. However, it remains an important component of a student's attitudes and perceptions with respect to education and career. In the present study, students were asked what occupation they expected to have at the age of 30. For the present study, Duncan's socioeconomic index was applied to the responses to produce a scalar variable.

Mathematics achievement is defined as the amount of mathematical skills and knowledge that an individual knows and possesses (Secada, 1992). In the present study, it was operationalized as a student's score on a standardized mathematics achievement test.

Justification for the Study

The present study is of both theoretical and practical interest. This is among the first attempts to study these variables using causal modeling techniques. As such, it is an opportunity to compare the support for the self-efficacy and goal-motivation theories. Research that is correlational in nature does not permit researchers to make inferences about the direction of cause-and-effect relationships, and structural equation modeling provides the best possibility for answering these questions. The study focuses on high-school students because this is a critical time period during which advanced mathematics concepts are being learned, and career goals are being formulated.

Gender is considered as a potential moderator of effects. Since previous research has shown differences in males' and females' attitudes towards mathematics, in their career aspirations, and in their achievement, possible differences in the causal ordering of these variables should also be considered.

The findings may also be of direct practical benefit in assisting high school students to succeed in mathematics, because interventions generally assume some form of cause and effect relationship. For instance, an intervention program may assume that enhancing self-efficacy will have an impact on career choice, or that helping a student to clarify her career goals will affect her mathematics achievement. Data that elucidates the true underlying causal processes will help in designing interventions. The variable that has the causal priority may also be considered the treatment priority. If intervention targets this variable, then improvements are likely to be followed by positive gains in the other target variables. This will help educators to develop and select interventions most likely to be effective, a necessity in fiscally conservative times.

Limitations of the Study

The objective of this study is primarily to begin to unravel the nature of the causal relationships between mathematics achievement, math attitudes, and career aspirations. The importance of career aspirations in this study is as a component of the student's attitudes toward math and their personal achievement and self-concept. Career aspirations in this sense cannot necessarily be equated with actual career choices.

Analytically, this study examines absolute causal relationships, that is, causal relationships which hold true for the sample as a whole. Relative ones are not addressed, with the exception of comparison between males and females. Other potentially relevant variables—socio-economic status, program of academic study, and ethnicity for instance—are not included in this study.

Finally, only relationships between pairs of variables--achievement and attitudes, attitudes and career aspirations, career aspirations and achievement—are examined in a

simplified, isolated fashion. Possible interrelationships among all three variables are not explored.

CHAPTER 2: REVIEW OF THE LITERATURE

This chapter reviews existing research literature on the relationships between mathematics achievement, career aspirations, and attitudes toward mathematics. First, the relationship between achievement and career aspirations is considered. The putative role of self-efficacy is considered, as well as other alternative explanations for the relationship. The literature on the relationship between mathematics achievement and attitudes toward mathematics is then discussed. Finally, the relationship between career aspirations and attitude is explored.

Mathematics Achievement and Career Aspirations

The relationship between achievement and career aspirations has been consistently established in numerous studies internationally (e.g. HRDC, 2001; Ma & Wang, 2001). In a study of the relative impact of factors on mathematics achievement scores, students' career aspirations were found to be among the strongest predictors of mathematics achievement, both in Canadian and international studies (HRDC, 2001). Using a stratified national sample of American high school students, Ma and Wang (2001) found that students' educational attainment was the best among several predictors of career aspirations, compared to quantity or quality of instruction, and motivational, home, class, peer, and media variables. Kreger (1988) found that such a correlation between mathematics achievement and career aspirations exists for girls even as early as grade 8.

Self-Efficacy as a Possible Explanation

One popular explanation for the relationship between mathematics achievement and aspiration toward math-intensive careers utilizes Bandura's self-efficacy theory.

Bandura (1977) stated in his social cognitive learning theory that the manner in which individuals perceive themselves will affect how they behave. Self-efficacy is defined as the sum of those personal judgements that all humans make about how well they will perform in situations that are ambiguous, unpredictable, and/or stressful. Positive self-efficacy perceptions are linked to both persistence and accuracy, which in turn influence performance. Individuals with low self-efficacy may avoid certain behaviours even if they possess the necessary skills, and even though these behaviours have the ability to produce desired outcomes. Bandura considers self-efficacy to be a cognitive phenomenon rather than an attitudinal one, a judgement regarding one's capability (Bandura, 1986). Still, it has been shown to correlate with attitudinal measures (Bandura, 1993).

Bandura (1977) identified four main sources of efficacy information: performance accomplishments, vicarious experiences, verbal persuasion, and emotional arousal.

Performance accomplishments are often regarded as one of the most direct and reliable sources of self-efficacy information. Successful experiences tend to increase expectations of self-efficacy, while repeated failures lower them (Roth, 1985). If self-efficacy is strong, an occasional failure would likely not diminish self-efficacy. Rather, the effects of success and failure experiences depend on the timing and sum total of several experiences (Bandura, 1977).

The second source for efficacy information is that of *vicarious experiences*. When a student observes a teacher or another student modeling the skills, this may enhance that student's belief that (s)he too can perform these same skills. It is thought that vicarious information has less of an effect on self-efficacy than performance accomplishments. In fact, it has been pointed out that vicarious observation can lead to

lowered self-efficacy if students observe others acquiring mastery readily while they themselves do not (Schunk, 1982).

The third source Bandura identified is *verbal persuasion*. Information is derived from the verbal suggestions of others. Mathematics teachers occasionally attempt to persuade students to work harder by stating that they have the capability to do well. Again, this must be followed by performance accomplishments; efficacy expectations induced by verbal persuasion are thought to be weak due to the possibility of disconfirming information (Roth, 1985).

Bandura called the fourth source of self-efficacy information *emotional arousal*. Aversive arousal, anxiety, and tension are associated with lowered self-efficacy.

Betz and Hackett (1983) invoked self-efficacy theory in discussing the career choice process, especially math-intensive career choices. They defined mathematics self-efficacy (MSE) as beliefs about one's ability to perform a variety of mathematics tasks, problems, and coursework, and argued that this is associated with choice of careers in the mathematics/science field. MSE could account for a correlation between mathematics achievement and mathematics-related career aspirations, since prior achievement serves as the most direct source of mathematics self-efficacy information (King, 1995), and mathematics self-efficacy is an important factor as to whether the student is likely to pursue a mathematics-intensive career. In North America, it is commonly held that mathematics learning is a matter of ability rather than effort, and a lack of accomplishment is regarded as a permanent state over which one has little control (McLeod, 1992). For this reason, self-efficacy may be particularly important in mathematics learning.

King (1995) found, in his study of African American high school seniors in middle Georgia, that mathematics achievement did indeed predict mathematics self-efficacy, which in turn predicted pursuit of math-related careers. King also identified other variables linked to mathematics self-efficacy, including low mathematics anxiety, general academic self-efficacy, and whether the student's mother had a college degree.

Task Value as an Alternative Explanation

It is also possible that career aspirations have an effect upon achievement, as a motivator. This hypothesis, an alternative to self-efficacy theory, is referred to as task value. Meece et al. (1982) write:

> For example, a female student who wants to be a veterinarian knows she must take advanced high school mathematics courses to gain entry into the appropriate college program. Consequently, she may take advanced mathematics classes, even though she has little or no interest in mathematics itself. In this case, the desirability of her career goal and the instrumentality of mathematics in helping her to achieve that goal outweigh her negative or neutral attitude toward the subject matter itself. The utility value of mathematics in this case is high because of its long-range usefulness. (pp. 339-340)

Thus, in the task value hypothesis, career aspiration is thought to have the causal priority, and achievement is believed to be a function of a student's motivation to perform. This belief is implicit in interventions where low-achieving students are proffered vocational guidance to help them formulate long-term goals. It is supposed that well-formed goals will motivate improved performance in coursework.

Research Evidence for Causal Directionality

Most research into the relationship of achievement with career aspirations has been correlational, and relatively few of the existing studies justify any inferences about causality. One interesting exception is Luzzo, Hasper, Albert, Bibby, & Martinelli's (1999) experimental investigation with college students. This study showed that a manipulation of mathematics self-efficacy had an impact on students' interests, goals, and actions with respect to mathematics intensive curricula and careers. Subjects were randomly assigned to one of four treatment conditions: performance accomplishment only, vicarious learning only, combined treatment, and a control group. Those in the *performance accomplishment* group were given a very easy task that they were told was a test of their mathematical abilities, and were all given passing marks. Participants in the *vicarious learning* group viewed a 15-minute video presentation showing two university graduates who discussed their personal experience of how they increased their confidence in mathematics and science and subsequently experienced success in these respective fields. Those in the combined group received both interventions. Measures taken both immediately after treatment and four weeks later showed that the *performance accomplishment* and *combined* groups showed greater interest in math/science careers, as well as actual increases in enrollment in math/science courses for the following quarter. Luzzo et al. concluded that performance accomplishments have a causative effect upon self-efficacy and choice of mathematics-related careers.

Mathematics Achievement and Perceived Importance of Mathematics

It is now widely recognized that affective and attitudinal issues are central to mathematics learning (McLeod, 1992). Generally speaking, affect can be defined as

"emotion or mood state," (Zimbardo, 1992, p. G-1) and attitude as "a learned, relatively stable tendency to respond to people, concepts, and events in an evaluative way" (Zimbardo, 1992, p. G-2). Sherman and Fennema (1977) showed the importance of attitude in mathematics learning. They found that when high school students' prior achievement and curriculum choice were controlled, their attitudes still affected achievement and intentions to study mathematics.

Some research has used causal modeling techniques to investigate the causal predominance of attitude and achievement. Using cross-lagged panel analyses, Minato and Kamada (1996) found that in the few cases where evidence for causal predominance was found, attitude appeared to have a greater effect upon achievement than the reverse. Ma and Kishor (1997)'s meta-analysis found that while a relationship between mathematics achievement and mathematics attitudes could be seen, there was no evidence to support a practically-significant causal relationship in either direction. Ma (2003), also using a cross-lagged longitudinal panel analysis, found support for the premise that poor achievement seems to be the cause of attitudes, rather than the reverse.

Research findings have not always been consistent because attitude toward mathematics has neither been defined nor measured in a consistent manner across studies (MacLeod, 1992). Indeed, there are several components of attitude toward mathematics, including liking for mathematics, mathematics anxiety, and perceived importance/usefulness of mathematics. Minato and Kamada (1996) for instance, do not specify what aspect of *attitude toward mathematics* was utilized, or how it was operationalized, in their research. The present study avoided the problem by being very specific about attitude. It focused on perceived importance, that is, the degree to which

mathematics is perceived as important, valuable, or relevant. Perceived usefulness has been shown to be inversely related to mathematics anxiety (Kincaid & Austin-Martin, 1981) and to be a significant predictor of mathematics dropout (Chisholm, 1980).

Cognitive dissonance theory offers a possible alternative as to why a relationship between achievement and perceived importance might be observed. Cognitive dissonance theory, which was introduced by Festinger (1957), has since been expanded to emphasize behavioural and attitudinal components (e.g. Aronson, 1968; Triandis, 1971). According to this theory, most individuals have a need to see themselves as reasonable, moral, and smart. When an individual is confronted with information implying that he or she has behaved in an unreasonable, immoral, or foolish manner, they experience an unpleasant state called cognitive dissonance, and are motivated to alleviate this dissonance and restore positive self-esteem. There are three ways that individuals may do so. They may change their behaviour in order to be consistent with their beliefs. They may change their beliefs. Or they may add *consonant cognitions* that serve to moderate the dissonance between behaviour and beliefs. For instance, in the case of mathematics learning, students who perform well would be more likely to believe thereafter that mathematics is more important or relevant. Students who perform poorly are likely to justify themselves by asserting that mathematics is not as important, since it is easier to introduce this consonant cognition than it is to improve their performance.

Career Aspirations and Perceived Importance of Mathematics

It appears likely that perceived importance is a function of one's career aspirations. Ideas of importance, relevance, or usefulness of mathematics must be established with respect to some purpose or objective such as future career prospects.

According to task value theory, perceived importance may mediate the relationship between career aspirations and mathematics achievement. Students who aspire to highly technical or professional careers are more likely to regard mathematics as relevant, and might therefore invest more effort, resulting in higher achievement.

Little research has been done to address the relationship between career aspirations and perceived relevance. Paula-Ann Pricken (1989) conducted a longitudinal study of 95 university students in an introductory calculus course. In this study, it was found that self-reports of mathematics self-efficacy did not significantly predict career choices, but that perception of the value of mathematics did. It was suggested that the failure of self-efficacy measures to predict the pursuit of math-related careers was due to restriction of range, since the entire population was already enrolled in calculus and the mean level of reported mathematics self-efficacy was quite high.

Gender

Much research has been devoted to gender differences in mathematics participation, achievement, and attitudes, with the objective of enhancing female mathematics participation (see Ma, 1997).

Gender Differences in Achievement

The term *gender gap* is commonly used to refer to the discrepancy in achievement between males and females at the upper secondary and college level, as well as to the under-representation of women in math-intensive careers.

It has been suggested (e.g., Benbow & Stanley, 1980; Bock & Kolakowski, 1973) that differences in mathematics achievement and participation between males and females are due to innate differences in ability. Based on this premise, it could be argued

that no real problem exists: women participate less in advanced mathematics because they are, on the average, less able in this area. However, Benbow and Stanley's conclusions were based on their longitudinal Study of Mathematically-Precocious Youth (SMPY), which focused on students in the top 3% of mathematics achievement. It is now widely held that their conclusions do not transfer to the general population, and many researchers now believe that the overall achievement gap may be attributable to gender differences in mathematics course enrollment (e.g. Berryman, 1983; Fennema, 1980; Fennema & Sherman, 1977a; Oakes, 1990; Pallas & Alexander, 1983; Smith & Walker, 1988; Wise, Steel, & MacDonald, 1979). It has been suggested that the findings of Benbow and Stanley are due to the fact that males are more variable than females in some cognitive abilities, including mathematics ability, and therefore research on gifted populations will generally have a greater proportion of males. This is consistent with the findings that while the gender gap has diminished in normative samples (Feingold, 1988; Hyde, Fennema, & Lamon, 1990; Rosenthal & Rubin, 1982) the same trend has not been seen among the most gifted populations (Lubinski, Benbow, & Sanders, 1993).

Gender Differences in Attitudes

What then is the cause of differential course enrollment? In a study of university undergraduates, Benton (1978) found that men perceived mathematics as more relevant than women, and that students' curriculum choices appeared to be related to perceived usefulness rather than ideas of sex-role appropriateness.

Jensen (1997) found that while the gender gap in curriculum and career choices has all but disappeared, gender differences in attitudes toward mathematics continue to persist. Gender differences continue to be seen in mathematics confidence, mathematics

anxiety (AAUW, 1991), and liking for mathematics (Thorndike-Christ, 1991), but not in perceived usefulness (Thorndike-Christ, 1991).

Betz and Hackett (1983) and Hackett (1985) showed that male and female college students differed in their levels of mathematics self-efficacy. Using path analysis, Hackett (1985) found that the effect of gender on mathematics self-efficacy was mediated by years of high school mathematics and mathematics achievement as measured by ACT-Math scores (American College Tests – Mathematics scores). Lapan, Boggs, and Morrill (1989) demonstrated that self-efficacy for various types of occupation in turn mediates many of the gender differences in occupational interests for university students.

Critical Synthesis

This chapter has reviewed the literature regarding the relationship between mathematics achievement, career aspirations, and attitude toward mathematics, as well as gender differences in each of these areas. The relationship of mathematics to career aspirations has been well established. This relationship can be accounted for by the mathematics self-efficacy and task value theories. However, the two theories make opposite predictions regarding the *direction* of causality. The true direction of causality remains ambiguous.

Likewise, there has been considerable research establishing the relationship between mathematics achievement and attitudes toward mathematics. One difficulty has been the lack of consistency in defining and operationalizing mathematics attitude. In fact, there seem to be several important components of attitude toward mathematics.

Little research has addressed the relationship between career aspirations and perception of the value/importance/relevance of mathematics. Again, though some

studies (e.g. Pricken, 1989) make statements that imply causality, the true direction of causality is unknown.

The gender gap in mathematics achievement and participation has decreased over the past few decades, although differences in some aspects of attitude toward mathematics remain. The achievement gap appears to be attributable to differences in mathematics course enrollment.

Few studies have sought to determine the direction of causality in the relationships between mathematics achievement, career aspirations, and attitude toward mathematics. Studies addressing directionality are more difficult to accomplish than correlational ones, because they require the use of longitudinal data, as well as elaborate statistical models such as path analysis and structural equation modeling (SEM) with cross-lagged design. The present study expanded our present understanding of the interrelationship of these variables by utilizing SEM to determine the causal ordering of the three variables.

CHAPTER 3: METHOD

There have been only a few studies using causal modeling to study high school mathematics learning. Using cross-lagged panel analyses, Meece et al. (1982) found that students' estimates of the relative worth of the effort needed to do well in mathematics influenced their expectations of future success, confidence in their mathematical ability, and their interest in mathematics. Ma (2003) used a similar technique to demonstrate that mathematics achievement generally has causal priority over mathematics attitude rather than the reverse. The present study uses a cross-lagged causal analysis strategy to determine the causal ordering between: (a) mathematics achievement, (b) career aspirations, and (c) perceived importance of mathematics.

The strategy will be discussed in detail in this chapter. Separate analyses were conducted for each pair of variables. In order to determine whether there is a gender difference in the relationships between these variables, a separate set of analyses was also conducted for the male and female subsets of the sample.

Sample for the Study

Data for the present study came from the Longitudinal Study of Mathematics Participation (LSMP), a research project conducted in the Canadian Centre for Advanced Studies of National Databases at the University of Alberta. The LSMP followed a sample of high school students from Grade 10 to 12, with the intention of identifying what student, teacher, and school characteristics contribute to decisions of mathematics participation.

The LSMP began in the spring of 2000 by surveying Grade 10 students in 34 schools from 11 school districts in the central part of the province of Alberta, Canada. In

each participating school, all Grade 10 students with parental consent participated in the LSMP. The sample contained a total 1,518 tenth graders with 155 mathematics teachers in 34 schools. These students were followed for three years. About 60% of the sample remained through the entire three-year span: 1066 students remained in grade 11 and 893 students in grade 12. Student, teacher, and principal questionnaires were used each year to collect data about students, teachers, and schools, together with a mathematics achievement test to measure students' mathematics competence.

This body of longitudinal data fits the purpose of the present study because it allows the use of causal modeling techniques such as path analysis and structural equation modeling. In these methods, data are acquired for each of the variables in a cohort population sample, longitudinally over time. These statistical procedures examine the relationships between the variables at different points in time, making it possible to infer the direction of causation.

High school students are an ideal population for the present study because high school is a critical period for mathematics education. First, it is generally in high school that most students begin to make definitive choices about college majors and careers (King 1995). Second, students' self-efficacy, as well as their attributions for success and failure, are well formed during high school grades. Finally, high school is an important time for mathematics learning, and graduates entering post-secondary with insufficient mathematics training face severely restricted career options, since mathematics is a critical filter for many careers.

Variables

Four variables were the focus of the present study: gender, mathematics achievement, career aspirations, and perceived importance.

Gender

Gender was based on the students' reports as coded on the student questionnaire. It was coded as a dummy variable, with 0 for female and 1 for male.

Mathematics Achievement

Mathematics achievement (Ach) was defined as amount of mathematical skill and knowledge that an individual knows and possesses (Secada, 1992), and was operationalized as the students' performance on a mathematics achievement test administered at the same time as the questionnaires. This was the mathematics subtest of the *Canadian Achievement Tests* (2nd ed.) (CAT/2) (Canadian Test Centre, 1992). The CAT/2 is a commercially available test geared to the Canadian curriculum. The Level 19 mathematics subtest consists of 45 multiple choice questions suitable for high school-level students. These assess student ability to understand mathematical concepts, and to apply this understanding to solve mathematical problems.

Career Aspirations

Career aspirations (CA) was based on students' response to an item in the student questionnaire which read: "What kind of work do you think you are *most likely* to be doing when you are 30 years old?" Students were asked to select from 13 classes of careers (see Appendix A). *Duncan's socioeconomic index* was then applied to their selections to produce a scalar variable. Duncan's socioeconomic index appears as part of

the final report of the North-Hatt prestige study in Reiss' (1961) *Occupations and Social Status*. It rank-orders occupations according to income and prestige. These ranked occupations are in an ordinal scale. Following the procedure outlined by Mosteller and Tukey (1977), they were converted to a continuous variable by normalization, making them suitable for data analysis. Thus, CA was rendered as a standardized variable, suitable for data analysis.

Perceived Importance

Perceived importance (PI) was treated as a latent variable based on students' responses to a ten-item scale on the student questionnaire (see Appendix B). The item listed ten mathematics topics that were covered in that year's curriculum. These topic headings were taken from the ten mathematics topics of the *Western Canadian Protocol for Collaboration in Basic Education* (2000). The item asked students to rate them on both importance and difficulty on Likert scales anchored at 1 (*Not important* or *Not difficult*), and 7 (*Very important* or *Very difficult*.)

Statistical Procedures

The primary statistical technique used in this study was structural equation modeling. A structural equation model contains a measurement model and a structural model. The measurement model was first fitted over three waves of longitudinal data on each of the three variables, and its validity assessed. A structural model was then developed based on the measurement model. Correlated measurement errors over time were considered, following sound statistical practice when modeling longitudinal data (Pitts, West, & Tein, 1996). As a standard statistical procedure, measurement errors among indicators were correlated at each time point.

Measurement and Structural Modeling

The measurement model was built using the Mplus statistical program. The data from the achievement tests and student questionnaires were inputted as indicators of latent variables, and the variables were fitted by the program in a process akin to confirmatory factor analysis (Figure 3.1). The variable *Career Aspirations* was treated as latent variable with a single indicator, that is, the relevant item on the Student Questionnaire. The variable *mathematics achievement* is treated as a latent variable, also with a single indicator, that is, the score on the CAT 2. The variable, *perceived importance* is a latent variable for which the ten *perceived importance* items on the student questionnaire were used as indicators.

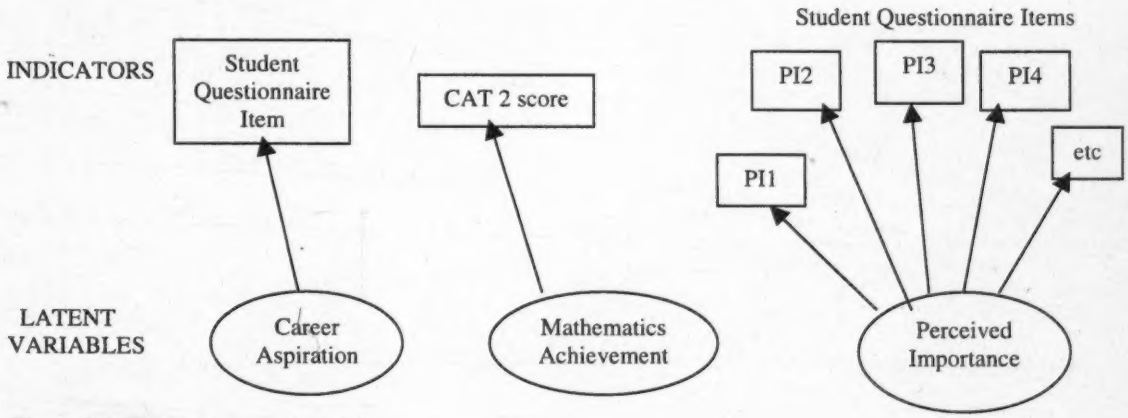


Figure 3.1. The measurement model.

For *perceived importance*, the factor loadings of each indicator were constrained to be constant across all three time points. That is, the loadings of each factor were kept consistent for Grade 10, 11, and 12. This ensured that PI was the same variable at all three time points.

The structural modeling process specifies variables at different time points to make inferences regarding the direction of causality. Path coefficients between one

variable at one time point and another variable at the next time point are called *cross-lagged* analyses and are represented by the solid lines in Figure. 3.2. The relative magnitudes of cross-lagged effects are taken as indices of causal directionality. *Stability effects* are also specified (dotted lines.) These refer to the relationships between measurements of one variable over time.

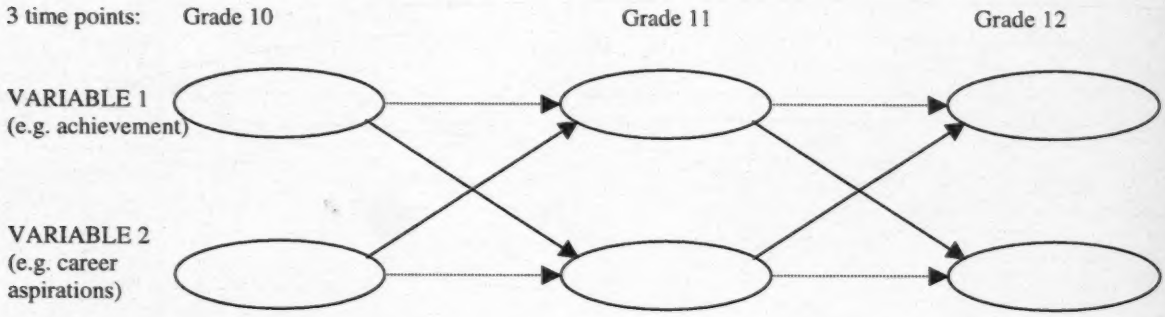


Figure 3.2. The general structural model

Simple variance-covariance matrices (male, female, and combined) were generated using all of the indicators of each of the three latent variables. The use of multiple indicators for PI enhanced the reliability of the structural model.

Measures called *model-data-fit indices* are used to assess the degree to which a model fits the data. In the present study, multiple model-data-fit indices are used, because they provide slightly different perspectives and ensure a more conservative and reliable assessment of the model (Jaccard & Wan, 1996). The Chi-Square Test of Model Fit (Jaccard & Wan), the Criterion Fit Index (CFI, Bentler, 1990), the Tucker-Lewis index (TLI), and the Standardized Root Mean Square Residual (SRMR) were used. Of these, the Chi-Square Test is the most popular, however, it has a tendency to over-reject models when sample size is very large. The CFI judges model-data-fit by comparing the model's predictive ability with that of a non-model. SRMR judges fit on the basis of the

magnitude of the residual, that is, the amount of variance in the data that the model does not account for.

CHAPTER 4: RESULTS

Descriptive statistics (mean and standard deviation) were obtained for the measures using SPSS. Correlations between the measures were also determined. Finally, using the Mplus program, structural equation modeling was used to compute path coefficients as per the measurement and structural models discussed in Chapter 3. These findings are reported in this section.

Descriptive Statistics

Table 4.1 displays the summary of means and standard deviations for Ach and PI for each grade, males, females and total. All measures are in raw scores: Ach scores are in raw point scores on the achievement test, and PI measures are in Likert scale points anchored at 1 and 7, with greater values representing greater perceived importance. As mentioned previously, the present study used existing data from a large-scale survey. For this reason, CA measures had been encoded as standardized scores with means of 0 and standard deviations of 1, based on a scale describing perceived future occupation. For this reason, statistics for CA are not recorded in Table 4.1.

Average achievement on the CAT mathematics section can be seen increasing from one year to the next as new skills and knowledge are acquired, and this pattern is observed in both male and female subsamples as well. Findings are consistent with the literature in that overall differences in achievement between males and females are very small. They range from 0.52 points in Grade 10 to 1.46 in Grade 11, representing a small gap. The standard deviations ranged from 6.64 to 8.85. Findings are also consistent with

previous research in that standard deviations for males are larger than the standard deviations for females.

On the average, females every year generally rated most areas of mathematics to be slightly less important than their male classmates, but differences are small. The area with highest PI ratings was PI2 (Number Operations). Ratings for the overall group were 5.60, 5.66, and 5.63 in Grades 10, 11, and 12 respectively. As described in the questionnaire, Number Operations encompasses "*using arithmetic operations* (e.g., multiplication, division, estimation, matrix operations, spreadsheets, compound interest, exchange ratios, taxes, insurance, accounting)." It is easy to understand why this might be ranked highest overall, since understanding and competence with these basic functions are required by most people for their basic household finances at least. PI8 (Transformations) received the lowest overall PI ratings: 3.55, 3.31, and 3.33 in the overall mean for each grade. Transformations was defined in the questionnaire as "*changing the shape and direction of graphs and patterns* (e.g. reflection, translation, compression, and rotation of graphs, functions and equations, etc.)". In contrast with Number Operations, Transformations represents an area whose practical applications may not be well understood by many high school students. There is little in the way of discernible trends in the means of PI indicators, but it can be noted that PI ratings for the overall group are generally lowest in Grade 11. Standard deviations for PI ranged from 1.28 to 1.74.

A correlation matrix was generated showing the Pearson product moment correlations between all measurements of Ach, CA, and PI for the entire sample. These can be seen in Appendix C.

No significance tests were applied to the correlations, as they are not the focus of the present research. The correlations served primarily to detect or to rule out the existence of colinearity between variables. The term colinearity signifies a very high correlation between two or more variables, and this could compromise the inferences that could be made from path coefficients. No serious colinearity was found among any of the measurements.

Table 4.1

Descriptive Statistics

	ACH		PI1		PI2		PI3		PI4		PI5		PI6		PI7	
	Mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
Grade 10																
Males	23.39	7.44	4.29	1.70	5.41	1.61	4.47	1.62	4.03	1.80	4.09	1.77	5.10	1.65	4.15	1.72
Females	22.87	6.64	4.21	1.53	5.80	1.37	4.46	1.50	3.94	1.65	4.02	1.63	5.03	1.48	3.98	1.55
Total	**23.14**	**7.06**	**4.25**	**1.62**	**5.60**	**1.51**	**4.46**	**1.56**	**3.98**	**1.73**	**4.05**	**1.70**	**5.07**	**1.57**	**4.07**	**1.64**
Grade 11																
Males	26.69	8.16	4.20	1.54	5.48	1.46	4.38	1.55	3.82	1.79	3.84	1.70	5.16	1.51	3.95	1.58
Females	25.23	7.30	4.13	1.45	5.81	1.34	4.31	1.55	3.58	1.51	3.66	1.58	4.94	1.51	3.71	1.47
Total	**25.77**	**7.80**	**4.16**	**1.51**	**5.66**	**1.41**	**4.36**	**1.56**	**3.68**	**1.65**	**3.74**	**1.65**	**5.04**	**1.51**	**3.81**	**1.55**
Grade 12																
Males	28.72	8.85	4.37	1.67	5.40	1.56	4.55	1.56	3.94	1.79	3.80	1.75	5.19	1.61	3.91	1.66
Females	27.35	7.55	4.34	1.43	5.87	1.28	4.45	1.42	3.59	1.49	3.67	1.58	4.99	1.45	3.70	1.41
Total	**27.92**	**8.25**	**4.36**	**1.55**	**5.63**	**1.45**	**4.50**	**1.50**	**3.78**	**1.67**	**3.75**	**1.68**	**5.09**	**1.54**	**3.83**	**1.56**

Descriptive Statistics continued

	PI8		PI9		PI10	
	mean	s.d.	mean	s.d.	mean	s.d.
Grade 10						
Males	3.58	1.71	4.52	1.69	4.23	1.73
Females	3.53	1.55	4.50	1.62	4.22	1.55
Total	**3.55**	**1.63**	**4.51**	**1.66**	**4.22**	**1.66**
Grade 11						
Males	3.44	1.64	4.50	1.62	3.97	1.74
Females	3.21	1.40	4.54	1.54	3.89	1.56
Total	**3.31**	**1.53**	**4.52**	**1.58**	**3.92**	**1.66**
Grade 12						
Males	3.43	1.68	4.70	1.65	4.10	1.73
Females	3.20	1.47	4.56	1.47	3.97	1.55
Total	**3.33**	**1.56**	**4.62**	**1.58**	**4.03**	**1.65**

Grade 10: n = 1518
Grade 11: n = 1066
Grade 12: n = 893

Structural Equation Modeling

The Mplus program generates estimates of the path coefficients between specified variables, for both the stability effects and the cross-lagged effects. In this particular analysis, the path coefficient is an index of the size of causal effect of one variable on another. When this path coefficient is equal to or greater than 1.96 times the standard error:

$$\text{Est./S.E.} \geq 1.96$$

that path coefficient is significant at the 0.05 level.

Separate sets of analyses were performed for each pair of variables (Ach with CA, Ach with PI, and CA with PI). Within each of these major sets, analyses were performed for the entire sample as a whole, as well as for the male and female subsamples separately. Thus, nine analyses were performed in total. The findings of each analysis will be discussed in detail.

Mathematics Achievement and Career Aspirations

Model Data Fit

Tests of model-data-fit are statistical tests used to determine whether a model adequately describes a data set. Several such tests were used to assess the structural models. The Chi-Square Test of Model Fit (Jaccard & Wan), the CFI (criterion fit index, Bentler, 1990), the TLI (Tucker-Lewis index), and the SRMR (Standardized Root Mean Square Residual). Each test was applied to both the models for all the subjects as well as to the models that analyzed male and female paths separately. Results of the tests are reported for each pairing. The Chi-Square Test for the fit of the overall (overall)

structural model of mathematics achievement and career aspirations was 104.58 ($df = 5$, $p < 0.01$). Large sample sizes can easily distort the conventional chi-square test, however (Fassinger, 1987), and for that reason some common sample-insensitive model-data-fit indices were considered: the CFI, TLI, and SRMR. CFI was 0.96. CFI's of 1 indicate a perfect fit, and models with a CFI of 0.9 or greater are considered to possess superiour model-data-fit. TLI was 0.89. SRMR was 0.03. SRMR's approaching 0 are considered to be indications of good model-data-fit.

Tests of model-data-fit were also performed for the procedure in which males and females were sorted and separately modeled. In this case, the Chi-Square test was 104.58 ($df = 14$, $p < 0.01$). CFI was 0.95. TLI was 0.90. SRMR was 0.05. These figures indicate that both the gendered and overall models possess adequate data-model fit properties.

Path Coefficients

Findings in the structural equation model for Ach and CA are summarized in Figure 4.1. In this figure, paths that were significant at the 0.05 level are shown in solid lines, and nonsignificant paths with their coefficients are shown in dotted lines for purposes of comparison. *Stability effects*. All stability effects on variables across time were highly significant, with path coefficients consistently upward of 0.50 and as high as 0.83. This is to be expected; repeated measures of attitudinal or ability variables over time will generally have some stability. For instance, achievement in one grade will correlate highly with achievement in later grades.

In general, Ach scores were the most stable, having stability coefficients consistently upward of 0.70 for both time intervals and as high as 0.83. This may have been partly because the measurement consists of a large set of aggregated test items, and

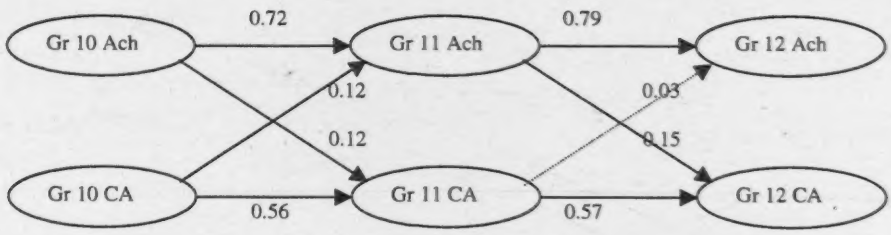
therefore the measurement is more reliable in terms of metric properties. Also, it is likely that overall quantitative/mathematics ability is somewhat more stable over time, while attitudes may shift and vary more from one year to another. Female stability effects for achievement were consistent for Grade 10-11 as well as from Grade 11-12. For males, however, achievement was especially stable between Grade 11 and Grade 12, with an estimated path coefficient of 0.83. Stability effects for career aspirations remained fairly consistently around 0.56 for both genders, for both time intervals.

Cross-lagged effects. In the cross-lagged analysis of achievement and career aspirations, it was found that the Ach10 on CA11 = 0.12, CA10 on Ach11 = 0.12, and Ach11 on CA12 = 0.15 path coefficients were significant at the $p < 0.05$ level. That is, for the sample as a whole, achievement in Grade 10 had an effect on career aspirations in Grade 11, career aspirations in Grade 10 had an equal-sized effect on achievement in Grade 11, and achievement in Grade 10 had an effect on career aspirations in Grade 11. Between Grade 10 and Grade 11, achievement and career aspirations have an equal and reciprocal or "criss-cross" effect, but only the effect of achievement upon career aspirations persists between Grade 11 and 12. In fact, it increases slightly in magnitude from a path coefficent of 0.12 to 0.15.

This becomes clearer, however, when the separate male and female analyses are considered. In the male sample, Ach10 on CA11 = 0.14, CA10 on Ach11 = 0.14, and Ach11 on CA12 = 0.21 paths were significant at the $p < 0.05$ level. However, in females, only Ach10 on CA11 = 0.10 and CA10 on Ach11 = 0.10 were found to be significant. Thus, only the "criss-cross" pattern between Grade 10 and Grade 11 was observed in the female subsample, and not the later effect of mathematics achievement

upon career aspirations, which is by contrast very large in the male subsample. The equipotential criss-cross is also present for males, and is somewhat greater in magnitude: 0.14 rather than 0.10. There also appears to be a substantial effect of Grade 11 Ach upon Grade 12 CA among male students that is not seen with female students. To summarize, between Grades 10 and 11, there appears to be an equal and reciprocal causal relationship between mathematics achievement and career aspirations both among male and female students. Males, but not females, show a strong effect of mathematics achievement upon career aspirations between Grade 11 and Grade 12. The analysis finds no relationship between achievement and career aspirations for females between Grades 11 and 12. The analyses provide support for the causal priority of achievement over career aspirations overall.

Overall



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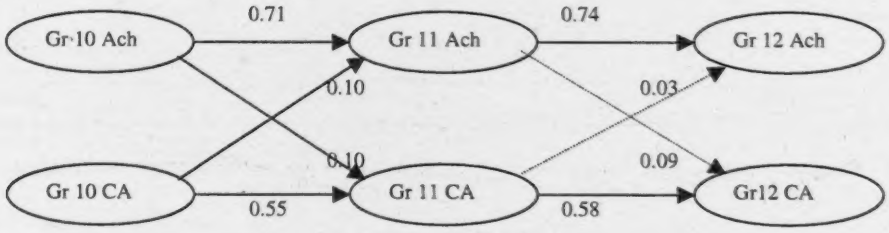

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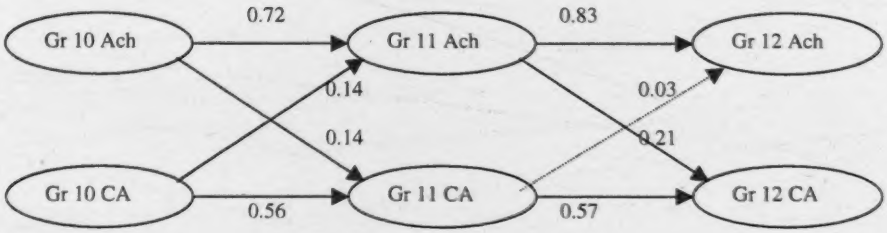


Figure 4.1. Models of the relationship between achievement and career aspirations

Mathematics Achievement and Perceived Importance

Model Data Fit

Again, model-data-fit was considered for this structural model. The overall model was considered first. The Chi-square test was 3518.48 ($df = 488$, $p < 0.01$). Again, due to the possibility that large sample size had biased the chi-square test, CFI (0.83), TLI (0.81), and SRMR (0.07) were measured. Model-data-fit for the gendered model was then considered. Chi square was 4331.44 ($df = 1032$, $p < 0.01$). CFI was 0.81, TLI was 0.81, and SRMR was 0.08. Model-data-fit is slightly less strong than the *achievement-career aspirations* model but fit is still fair.

Path Coefficients

Results are summarized in Figure 4.2. Significant paths are shown in solid lines and nonsignificant paths are shown in dotted lines.

Stability effects. Again, all stability effects on variables across time were highly significant, with Ach scores having the greatest stability. Stability effect coefficients are slightly different for the same variable in different analyses because different analyses have different errors, and this affects stability estimates slightly. Perceived importance also showed gender differences in stability effects. For females, PI was more stable between Grades 11 and 12 (estimates of 0.65 and 0.67) than between 10 and 11 (estimated at 0.53). For males, on the other hand, stability seems to have decreased slightly for the 11 to 12 interval (estimates of 0.60 and 0.61) compared to the 10 to 11 interval (0.66). Stability estimates are initially greater for females, but greater for males later.

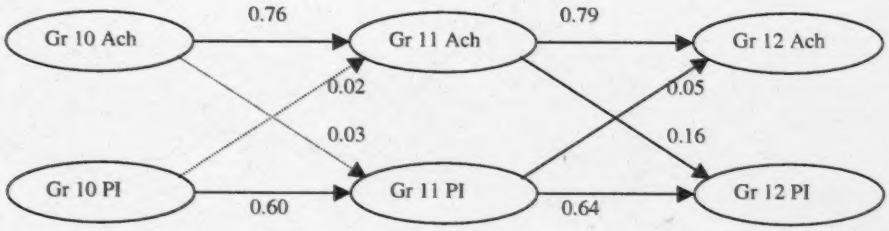
Cross-lagged effects. Findings for the combined (male and female) sample are considered first. In the cross-lagged analysis of achievement and perceived importance, path coefficients Ach11 on PI12 = 0.155 and PI11 on Ach12 = 0.053 were significant. That is, Grade 11 mathematics achievement had an effect on Grade 12 perceptions of the importance of mathematics, and Grade 11 perceived-importance also had a modest effect upon Grade 12 Achievement. Path coefficients between Grade 10 and Grade 11 ratings and scores did not reach the criterion of significance.

When independent analyses were conducted by gender, it was seen that again, males and females exhibit different patterns. Females also show the reciprocal paths (Ach11 on PI12 = 0.126; PI11 on Ach12 = 0.081). That is, females' mathematics achievement in Grade 11 influences their perceptions of the importance of mathematics in Grade 12, and their Grade 11 perceptions of the importance of mathematics also affects their Grade 12 mathematics achievement. The effect of Grade 11 Ach upon Grade 12 PI is somewhat larger than the converse effect of Grade 11 PI upon Grade 12 Ach (0.13 and 0.08, respectively). While a reciprocal causal relationship existed between mathematics achievement and career aspirations between Grade 10 and 11, this disappears between Grade 11 and 12, and instead a criss-cross occurs between achievement and perceptions of the importance of mathematics.

Males, on the other hand, show significance only on the Ach11 on PI12 path, a unidirectional effect with a rather large path coefficient of 0.20. This, along with the rather large 0.21 on the Ach11 on CA3 path for males, is the strongest of the cross-lagged effects seen in all of the analyses. This suggests that for male students toward the end of high school, prior mathematics achievement becomes especially important in determining

their attitudes—both their career aspirations as well as their perceptions of the importance of mathematics. The analysis of the data also suggests, rather surprisingly, that mathematics achievement and perceived importance have no causal relationship whatsoever between the years of Grade 10 and Grade 11, either for males or females. Where causality is apparent, the data support the causal priority of mathematics achievement over perceived relevance of mathematics.

Overall



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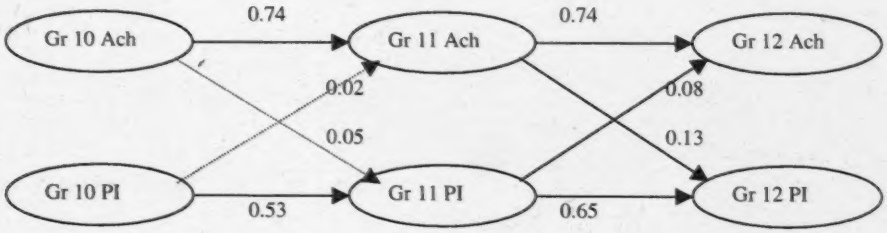

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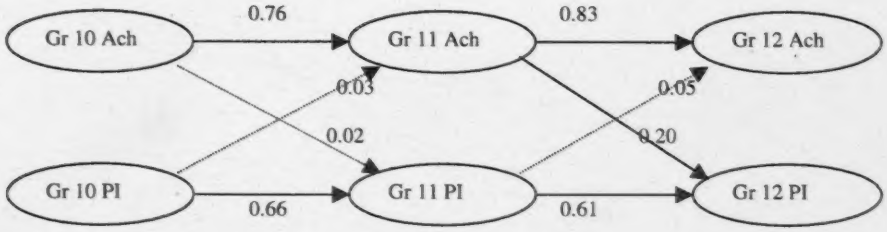


Figure 4.2. Models for the relationship between achievement and perceived importance

Model-data-fit

Again, model-data-fit was considered for this structural model. The overall model was considered first. Chi square was 3432.23 ($df = 488, p < 0.01$). CFI was 0.82, TLI was 0.81, and SRMR was 0.06. Model-data-fit for the gendered model was then considered. The Chi-square test was 4181.69 ($df = 1032, p < 0.01$). Again, due to the possibility that large sample size had biased the chi-square test, CFI (0.808), TLI (0.803), and SRMR (0.075) were applied. Based on the indices, model-data-fit is fair.

Path Coefficients

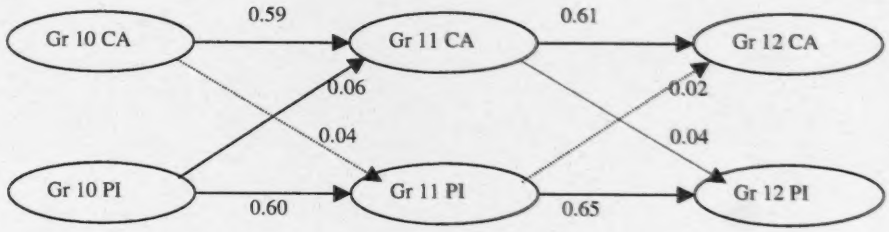
Stability effects. Stability effects for all variables have already been discussed in the previous two sets of models. There are very slight differences in stability coefficients from one analysis to another. Again, these are due to differing error from one model to the next, which affect stability estimates.

Cross-lagged effects. The cross-lagged analysis of career aspirations and perceived importance showed only one significant vector path: PI10 on CA11, with a modest path coefficient of 0.057, suggesting that for students in general, perceived importance of mathematics in Grade 10 affects career aspirations in Grade 11. However, once again, separate analyses by gender again paints a very different picture.

For females, only the path PI11 on CA12 = 0.092 is significant. That is, the effect of perceived importance upon career aspirations is not apparent in the interval between Grade 10 and Grade 11, but such an effect does occur between 11th and 12th grade. For males, PI10 on CA11 = 0.11 and CA11 on PI12 = 0.12 are significant. Thus, there was a "rebound effect" in which their perceptions of the importance of mathematics in Grade

10 had an effect on career aspirations on Grade 11, which in turn had an effect on their perceptions of importance in Grade 12.

Overall



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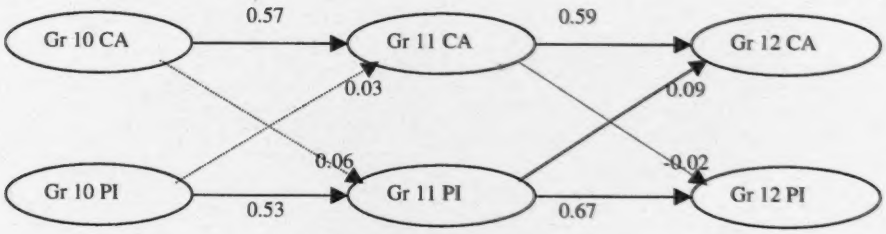

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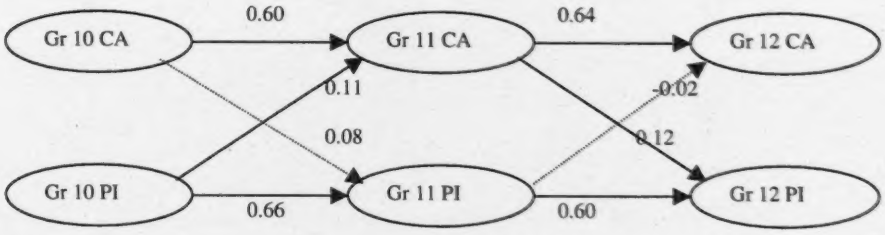

Figure 4.3. Models for the relationship between career aspirations and perceived importance

CHAPTER 5: DISCUSSION

Summary of Findings

In general, stability effects for mathematics achievement, career aspirations, and perceived importance of mathematics are very high. Mathematics achievement showed the strongest stability coefficients.

No single variable has causal priority over all others at all times for all students. What cross-lagged effects are present, as well as their magnitude, seem to be a function of gender and time. No test was performed specifically to determine the significance of difference between male and females in terms of their causal paths. However, the very different patterns of effects suggest that males and females are indeed distinct in terms of the way that mathematics attitudes and achievement relate during high school.

For the sample as a whole, achievement in Grade 10 had an effect on career aspirations in Grade 11; career aspirations in Grade 10 had an equal-sized effect on achievement in Grade 11, and achievement in Grade 11 had an effect on career aspirations in Grade 12. When separate analyses were conducted by gender, two things became apparent. First, it was striking that while the criss-cross effect between grade 10 and 11 was larger for males than females, career aspirations and mathematics achievement always had equal effects upon the other. Second, only the reciprocal ("criss-cross") pattern between Grade 10 and Grade 11 was observed in the female subsample. The later effect of mathematics achievement upon career aspirations was not seen with the female subsample, and is by contrast very obvious in the male subsample. A finding that achievement has causal priority over career aspirations is consistent with the

predictions of self-efficacy theory, suggesting that self-efficacy may have a particularly important role for males in the latter part of high school.

The second set of analyses addressed the relationship between achievement and perceived importance. No causal relationship was found between these variables between the years of Grade 10 and Grade 11. Grade 11 mathematics achievement had an effect on Grade 12 perceptions of the importance of mathematics, and Grade 11 perceived-importance also had a modest effect upon Grade 12 Achievement. But when independent analyses were conducted by gender, it was seen that again, males and females exhibit different patterns. Females also show the reciprocal paths, and the effect of achievement upon perceived importance was slightly greater than the converse path. Meanwhile for males only the path between Grade 11 mathematics achievement and Grade 12 perceived importance was significant. This too was a particularly strong effect, showing that Grade 11 mathematics achievement for males had substantial impact on both attitudinal measures—both career aspirations and perceptions of the importance of mathematics.

The analysis provides support for the overall causal predominance of mathematics achievement over both career aspirations and perceived importance of mathematics. Past research on the direction of causality between mathematics achievement and attitudes toward mathematics has yielded mixed results. One reason may be that attitude has been operationalized in different ways in different studies. There are many components of attitude toward mathematics, and these cannot be collapsed as a single variable. Another possibility that may be considered is that patterns of causal directionality may vary by grade (for instance, different patterns may predominate in the elementary junior high school years) as well as cross-culturally.

The cross-lagged analysis of career aspirations and perceived importance for the entire group showed only one significant vector path: that between perceived importance in Grade 10 and career aspirations in Grade 11, with a modest path coefficient of 0.06. For females however, the effect of perceived importance upon career aspirations is not apparent in the interval between Grade 10 and Grade 11, but such an effect does occur between 11th and 12th grade. For males, there was a "rebound effect" in which perceived importance of mathematics in Grade 10 had an effect on career aspirations in Grade 11, which in turn had an effect on their perceived importance in Grade 12. The findings for the overall group show little resemblance to the findings for the separate male and female analyses, again underscoring the importance of analyzing males and females separately.

It is noted that the largest effects in the set of analyses are those seen in males, between Grade 11 mathematics achievement and both career aspirations and perceived importance in Grade 12. This suggests that prior achievement has a particularly important effect upon attitudes in the later part of high school for male students. For females, Grade 11 perceived importance of mathematics is similarly notable in that it has paths to both career aspirations and achievement in Grade 12. However, path coefficients are not nearly as large, and in fact the path from Grade 11 Ach to Grade 12 PI appears to be stronger than the converse.

Contrary to expectations, perceived importance of mathematics is not consistently found to be a direct result of career aspirations. This may be because careers with a high Duncan's socioeconomic index are not always those which require more mathematics preparation, and a student may at once aspire to a prestigious career as well as avoid mathematics.

Implications for Research and Practice

Due to increasing demand for expertise in mathematics in the present society, both mathematics achievement and attitudinal variables are targets of intervention. Several models have been proposed (e.g. self-efficacy theory, task value hypothesis) that suggest a possible causal relationship between these variables. However, there has been little research to empirically explore the true nature of the causal relationships between these variables.

Causal modeling techniques allow us to identify the actual causal priority of these variables, rather than making assumptions based on theory. Thus, it becomes possible for educators to target for intervention those variables which appear to have causal priority, since they are more likely to refer changes to the other target variables.

The analyses do not support a "one-size fits all" approach to intervention. Strategies for enhancing mathematics learning and attitudes should be customized according to gender and grade level. Clearly, by Grade 12, male students' attitudes regarding the importance of mathematics, as well as their career aspirations, are largely a function of their achievement in Grade 11. For this reason, interventions which enhance achievement, such as tutoring or coaching approaches, may also have a referred benefit of higher career aspirations and positive attitudes toward math in the immediate future.

Between the years of Grade 10 and Grade 11, the equal, reciprocal "criss-cross" effects show that mathematics achievement and career aspirations are closely and reciprocally interrelated. This should be recognized by practitioners. In terms of interventions, neither career counseling and support, nor achievement-related interventions should be emphasized at the exclusion of the other.

During the same time period, however, there is no evidence for a causal relationship between mathematics achievement and a student's perception of the importance of mathematics. Such a relationship does emerge later. For both males and females, achievement clearly has the causal priority; however, for females, perceived importance in Grade 11 did have a significant effect upon grade 12 achievement. Theoretically, this is consistent with cognitive dissonance theory, which predicts that an individual's attitudes may change to align with his or her performance in order to restore positive self-esteem. It is important for educators to recognize that when high school students make statements regarding their perceptions of the importance of mathematics, this is in part a function of their prior achievement. These perceptions may respond to changes in achievement. It may be helpful, in teaching Grade 11 female students, to emphasize possible real-world applications of the mathematics skills being taught.

Strengths and Limitations

The present study had the advantage of large sample size, longitudinal data, and powerful statistical design. Studies such as this one are important because the cross-lagged, longitudinal design permits us to make fairly strong inferences regarding causality. Separate gendered analyses provided insight regarding differences in the ways that these variables relate for male and female students. Also, this is among the first studies to examine the relationship between career aspirations and perceived importance of mathematics longitudinally and using causal modeling techniques. Therefore, the results constitute pioneering findings, and offer tentative hypotheses for further research ahead.

Limitations to the study include analytic considerations: Model-data fit indices such as the CFI and TLI are borderline on the Ach-PI and CA-PI pairings. Stronger model-data fit would enhance confidence in these models. A chi-square test is perhaps not a fair indication of the model's adequacy. A chi square test is based on the comparison between a predicted set of correlations and an actual set of correlations. It assumes that all paths in the model are thought to be significant. However, this is not the case in the present study. Chi square tests also have a tendency to overreject the model when sample size is very large, as is the case here (n = 1513).

Weak results may also be related to limitations of the instruments. The measures of career aspiration and perceived importance of mathematics are fairly brief scales. The career aspirations measure uses rather coarse groupings of occupations. The forced choice between 13 categories avoids the difficulties that might be associated with a more open-ended item. However, it also provides researchers with less specific data. Also, it collapses into a single category several occupations with differing degrees of mathematics-relatedness. For instance, a geomatics engineer, a licensed practical nurse, and a professor of Russian literature would all be categorized under the heading: *professional, business, or managerial*. For this reason it was not possible to research how mathematics-relatedness of a student's anticipated career may be related to achievement and perceived importance.

Missing values due to attrition of participants are a concern, as in any other longitudinal study. Students may discontinue their mathematics coursework, emigrate from the area under study, or decline to participate in the study. Missing data adversely

affects model-data fit indices. It is also possible that the subset of participants whose data are missing has different characteristics than the rest of the sample.

Suggestions for Further Research

This study, consistent with previous research, finds that the interplay of achievement and attitudes is a function of gender and time. Further research in high school mathematics learning should continue to compare findings for males and females separately. A possible aim of research would be to determine the reasons for the differing paths for males and females.

The design of the present study considered only the three variables, and treated their pairings in an isolated manner. This did not allow for inferences to be made regarding possible mediator or moderator variables (other than gender and grade level). Integrating the three variables in a single model would allow for examination of the relationship between two of the variables while the third variable is controlled, so that mediator or moderator variables can be identified.

The present study used socioeconomic index to rank various occupations. Mathematics-relatedness was not studied, but this may be considered in future research. Mathematics-relatedness may indeed prove to be more pertinent than socioeconomic standing.

Other potentially important variables are not integrated into the models as they presently stand. For instance, the concept of mathematics self-efficacy has been invoked as a mechanism whereby achievement can affect attitudes, particularly career aspirations. Yet no direct measurements of self-efficacy, or of the numerous other attitudinal variables, were made in the present study. Future research should also consider other

attitudinal variables such as mathematics self-efficacy and its possible role, whether as a causal agent, mediator variable, or in terms of the variables which might affect it.

Qualitative research may be useful in uncovering possible explanatory mechanisms for the pattern of results, or identifying differences in thoughts and attitudes of students with high and low mathematics achievement, career aspirations, and perceptions of the importance of mathematics.

REFERENCES

American Association of University Women [AAUW]. (1991). *Short-changing girls, short-changing America. A nationwide poll to assess self-esteem, educational experiences, interest in mathematics and science, and career aspirations of girls and boys ages 9-15.* Washington, DC: Author. (Eric Document Reproduction Service No. ED 340 657)

Aronson, E. (1968). Dissonance theory: Progress and problems. In R. P. Abelson, E. Aronson, W. J. McGuire, T.M. Newcomb, M. J. Rosenberg, & P. H. Tannenbaum (Eds.), *Theories of cognitive consisitency: A Sourcebook* (pp. 5-17). Chicago: Rand McNally.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavior change. *Psychological Review, 84,* 191-215.

Bandura, A. (1986). *Social foundations of thought and action: a social cognitive theory.* Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28,* 117-148.

Benbow, C. P., & Stanley, J. C. Sex differences in mathematical ability: Fact or artifact? *Science, 210,* 1262, 1264.

Bentler, P.M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin, 107,* 238-246.

Benton, B. L. (1979). Mathematics avoidance and pursuit of fantasy careers. (Doctoral dissertation, Southern Illinois University at Carbondale, 1978) *Dissertation Abstracts International,40,* 2818.

Berryman, S. E. (1983). *Who will do science? Minority and female attainment of science and mathematics degrees: Trends and causes.* New York: Rockefeller Foundation.

Betz, M.E. & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. *Journal of Vocational Behavior, 23,* 329-345.

Bock, R. D., & Kolakowski, D. Further evidence of sex-linked major gene influence on human spatial visualizing ability. *American Journal of Human Genetics, 25,* 1-14.

Bollen, K. A. (1989). *Structural equations with latent variables*. New York: Wiley.

Canadian Test Centre. (1992). *Canadian achievement tests* (2nd ed.). Markham, ON: Author.

Chisholm, C. (1980). *Correlates of math avoidance responsible for filtering individuals from math/science areas.* (ERIC Document Reproduction Service no. ED 220 345).

Fennema, E. (1980). Sex-related differences in mathematics achievement: Where and why. In L. H. Fox, L. Brody, & D. Tobin (Eds.), *Women and the mathematical mystique* (pp. 76-93). Baltimore: Johns Hopkins University Press.

Fennema, E. & Sherman, J. (1977a). Sex-related differences in mathematics achievement, spatial visualization and affective factors. *American Educational Research Journal, 14,* 51-71.

Fennema, E. & Sherman, J. (1977b). Sexual stereotyping and mathematics learning. *Arithmetic Teacher, 24,* 369-372.

Festinger, L. (1957). *A theory of cognitive dissonance.* Stanford, CA: Stanford University Press.

Human Resources Development Canada. (2001). *Measuring Up: The Performance of Canada's Youth in Reading, Mathematics, and Science: OECD PISA study: first results for Canadians aged 15.* (Statistics Canada Publication No. 81-590-XPE). Ottawa, Canada: Council of Ministers of Education Canada.

Jaccard, J.C., & Wan, C.K. (1990). *LISREL approaches to interaction effects I nmultiple regression.* Thousand Oaks, CA: Sage.

Jensen, J.A. (1997). Gender differences in the relationship of attitudinal and background factors to high-school students choice of math-intensive curriculum and careers. (Doctoral dissertation, Northern Illinois Unversity, 1997). *Dissertation Abstracts International*, 1998-95003-104.

King, J. D. (1995). Investigating the general and mathematics efficacy and attributions of African American students, as predictors of pursuit of mathematics-related careers. (Doctoral dissertation, University of Georgia, 1995). *Dissertation Abstracts International*, 3041.

Kreger, B. L. (1988). The relationship of mathematics achievement to expected career choice for females in grades three, five, and eight in a rural school district. (Doctoral dissertation, University of Pittsburgh, 1990). *Dissertation Abstracts International, 49,*1374-1375.

Lubinski, D., Benbow, C. P., & Sanders, C. E. (1993). Reconceptualizing gender differences in achievement among the gifted. In K. A. Heller et al. (Eds.) *International Handbook of Research and Development of Giftedness and Talent.*

Luzzo, A. L.. Hasper, P., Albert, A., Bibby, M. A., and Martinelli, E. A. (1999). Effects of self-efficacy-enhancing interventions on the math-science self-sfficacy and career interests, goals, and actions of career undecided college students. *Journal of Counseling Psychology, 46,* 233-243.

Ma, X. (2003, April) *A longitudinal study of the causal ordering between attitude toward mathematics and achievement in mathematics.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Ma, X. (1997). *A national assessment of mathematics participation in the United States: A survival analysis model for describing students' academic careers*. Lewiston, NY: Edwin Mellen.

Ma, X., & Kishor, N. (1997). Assessing the relationship between attitude toward mathematics and achievement in mathematics: a meta-analysis. *Journal for Research in Mathematics Education, 28,* 26-47.

Ma, X., & Wang, J. (2001). A confirmatory examination of Walberg's model of educational productivity in student career aspiration. *Educational Psychology 21,*443-453.

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575-596). New York: Macmillan.

Meece, J. L., Eccles Parsons, J., Kaczala, C. M., Goff, S. B., & Futterman, R. (1982). Sex differences in math achievement: Toward a model of academic choice. *Psychological Bulletin, 91,* 324-348.

Minato, S., & Kamada, T. (1996). Results of research studies on causal predominance between achievement and attitude in junior high school mathematics of Japan. *Journal for Research in Mathematics Education, 27,* 96-99.

Mosteller, F., & Tukey, J.W. (1977). *Data analysis and regression.* Reading, MA: Addison-Wesley.

Oakes, J. (1990). Opportunities, achievement, and choice: Women and minority students in science and mathematics. *Review of Research in Education, 16,* 153-222.

Pallas, A. M., & Alexander, K. L. (1983). Sex differences in quantitative SAT performance: New evidence on the differential coursework hypothesis. *American Educational Research Journal, 20,* 165-182.

Pricken, P. (1989). Gender differences in math achievement: the influence of math self-efficacy, attributions for math performance, and perceptions of the value of math on career choice outcomes. (Doctoral dissertation, Pennsylvania State University, 1989).

Reiss, A.J. (1961). *Handbook of research design and social measurement* (5th ed.) Newbury Park, CA: Sage Publications.

Roth, W. G. (1985). Treatment implications derived from self-efficacy research with children (Doctoral dissertation, Biola University, 1985). *Dissertation Abstracts International.*

Schunk, D. H. (1982). *Self-efficacy perspective on achievement behavior.* (Eric Document Reproduction Service No. ED 226 293)

Sherman, J. and Fennema, E. (1977). The study of mathematics by high school girls and boys: Related variables. *American Educational Research Journal, 14,* 159-168.

Smith, S. E., & Walker, W. J. (1988). Sex differences in New York State Regents Examinations: Support for the differential course-taking hypothesis. *Journal for Research in Mathematics Education, 19,* 81-85.

Thorndike-Christ, T. (1991). *Attitudes toward mathematics: Relationships to mathematics achievement, gender, mathematics course-taking plans, and career interests.* Bellington, WA: Western Washington University. (ERIC Documentation Reproduction Service No. ED 357 066).

Triandis, H. C. (1971). *Attitude and attitude change.* New York: John Wiley & Sons.

Western Canadian Protocol for Collaboration in Basic Education. (2000). [On-line]. Available: http://www.wcp.ca/general/wpagreement.html

Wise, L. L., Steel, L., & MacDonald, C. (1979). *Origins and career consequences of sex differences in high school mathematics achievement.* Unpublished manuscript, American Institute for Research, Palo Alto, CA.

APPENDIX A

Student Questionnaire Item 14: ABOUT YOUR CAREER PLANS

What kind of work do you think you are most likely to be doing when you are 30 years old? Mark the answer that comes closest to what you expect to be doing. If you have two or three things you think you may be doing, make ONE best guess. Do not pick more htna one.

CRAFTSPERSON OR OPERATOR such as baker, mechanic, chef, machine operator, electronics repair, bus driver, taxi driver, truck driver

FARMER OR FARM MANAGER

HOMEMAKER

LABORER OR FARM WORKER such as farm hand, garbage collector, car washer, construction worker

MILITARY, POLICE OR SECURITY such as career officer or enlisted person in the armed forces, police officer, security guard, firefighter, detective

PROFESSIONAL, BUSINESS, OR MANAGERIAL such as professor, teacher, librarian, nurse, doctor, dentist, restaurant manager, buyer, business executtive

OWNING a business or service establishment

TECHNICAL such as draftsman, dental technician, computer programmer

SALESPERSON, CLERICAL OR OFFICE WORKER such as sales clerk, real estate agent, newsstand operator, data entry clerk, secretary, bank teller

SCIENCE OR ENGINEERING PROFESSIONAL such as an engineer or scientist

SERVICE WORKER such as hairdresser, janitor, beautician, waiter, short-order cook, child care worker

OTHER _____

NOT WORKING such as retired or dependent.

APPENDIX B

Student Questionnaire Item 20: PERCEIVED IMPORTANCE

Below is a list of some mathematics topics that you have studied this year. We would like you to tell us 2 things about each topic:

a. How important do you think each topic is?
b. How difficult did you find each topic?

Please circle a number on each line. NOTE that

1 = Not important or Not difficult, and **7 = Very important or Very difficult.**

Number Concepts: *using numbers to describe quantities and representing numbers in different ways* (e.g. natural, whole, integer, reciprocals, roots, exponents, analyzing and completing tables of data, etc.)

Number Operations: *using arithmetic operations* (e.g., multiplication, division, estimation, matrix operations, spreadsheets, compound interests, exchange ratios, taxes, insurance, accounting, etc.)

Patterns: *using patterns to describe the world and solve problems* (e.g., speed and distance, rates of growth, using graphs to find a pattern, geometric and exponential patterns, mathematical reasoning, graphs of periodic events, fractals, etc.)

Variables and Equations: *representing expressions or relationships in different ways* (e.g., factoring polynomials, polynomial division, linear and non-linear equations, exponential and logarithmic equations, trigonometric functions and identities, etc.)

Relations and Functions: *using algebraic and graphical models to generalize, make predictions and solve problems* (e.g., graphing linear and non-linear functions, quadratic functions, trigonometric functions, using graphing calculators, etc.)

Measurement: *assigning numbers to everyday physical phenomena* (e.g. enlargint and reduction, calculating perimeter, area and volume, trigonometry, using measuring devices, analyzing cost and design, etc.)

3-D Objects and 2-D Shapes: *analyzing distance and dimensions of shapes and identifying relationships between them* (e.g. coordinates, grids, distance, lines and line segments, bisectors, properties of circles and polygons, vectors, conic sections, etc.)

Transformations: *changing the shape and direction of graphs and patterns* (e.g. reflection, translation, compression, and rotation of graphs, functions, and equations, etc.)

Data analysis: *collecting, representing, and analyzing data to make predictions about a population* (sampling techniques, making and analyzing charts and graphs, mean, median, model, line-of-best-fit, correlation, etc.)

Chance and Uncertainty: *using experiments or theories to predict uncertain events* (e.g. probability, permutations, combinations, fundamental counting principle, normal distribution, z-scores, etc.)

APPENDIX C

Intercorrelations of Mathematics Achievement, Career Aspirations, and Perceived Importance of Mathematics

	Grade 10											
	Ach10	CA10	PI1	PI2	PI3	PI4	PI5	PI6	PI7	PI8	PI9	PI10
Grade 10												
Ach10	1.00											
CA10	0.31	1.00										
PI1	0.07	0.07	1.00									
PI2	0.14	0.11	0.40	1.00								
PI3	0.12	0.06	0.48	0.42	1.00							
PI4	0.05	0.07	0.51	0.23	0.45	1.00						
PI5	0.03	0.06	0.45	0.26	0.49	0.68	1.00					
PI6	0.07	0.02	0.42	0.43	0.47	0.41	0.44	1.00				
PI7	0.07	0.02	0.41	0.28	0.51	0.50	0.52	0.53	1.00			
PI8	-0.06	-0.01	0.47	0.21	0.47	0.57	0.56	0.45	0.64	1.00		
PI9	0.07	0.01	0.43	0.34	0.47	0.41	0.44	0.49	0.47	0.47	1.00	
PI10	0.05	0.07	0.44	0.30	0.50	0.43	0.44	0.41	0.48	0.48	0.60	1.00
Grade 11												
Ach11	0.75	0.33	0.08	0.15	0.10	0.05	0.06	0.07	0.04	-0.05	0.05	0.06
CA11	0.28	0.59	0.10	0.11	0.09	0.12	0.08	0.05	0.02	0.01	0.10	0.05
PI1	0.00	0.04	0.43	0.20	0.31	0.32	0.33	0.26	0.25	0.31	0.27	0.25
PI2	0.01	0.17	0.27	0.33	0.28	0.16	0.18	0.27	0.20	0.18	0.25	0.23
PI3	0.07	0.07	0.23	0.19	0.36	0.18	0.24	0.26	0.26	0.29	0.22	0.23
PI4	0.05	0.05	0.26	0.11	0.28	0.43	0.34	0.22	0.30	0.34	0.14	0.21
PI5	0.00	0.04	0.23	0.12	0.26	0.37	0.36	0.19	0.26	0.32	0.17	0.18
PI6	0.12	0.05	0.20	0.18	0.27	0.21	0.23	0.29	0.29	0.28	0.23	0.21
PI7	0.07	0.06	0.26	0.16	0.34	0.30	0.26	0.26	0.35	0.35	0.27	0.27
PI8	-0.06	-0.01	0.24	0.07	0.30	0.36	0.30	0.19	0.31	0.39	0.23	0.24
PI9	0.03	0.12	0.20	0.18	0.27	0.18	0.19	0.26	0.21	0.24	0.31	0.27
PI10	0.09	0.08	0.19	0.11	0.26	0.21	0.18	0.18	0.21	0.24	0.27	0.30

Intercorrelations of Mathematics Achievement, Career Aspirations, and Perceived Importance of Ma

	Grade 10										
	Ach10	CA10	PI1	PI2	PI3	PI4	PI5	PI6	PI7	PI8	PI9
Grade 12											
Ach12	0.73	0.30	0.12	0.18	0.15	0.09	0.08	0.11	0.08	-0.02	0.0
CA12	0.30	0.48	0.03	0.13	0.05	0.10	0.08	0.03	0.04	-0.02	0.1
PI1	0.17	0.11	0.32	0.22	0.21	0.28	0.25	0.27	0.24	0.22	0.2
PI2	0.15	0.19	0.23	0.36	0.24	0.19	0.19	0.26	0.18	0.15	0.2
PI3	0.23	0.09	0.21	0.26	0.29	0.23	0.24	0.28	0.27	0.20	0.2
PI4	0.15	0.05	0.23	0.11	0.23	0.38	0.31	0.22	0.25	0.26	0.2
PI5	0.09	0.07	0.20	0.11	0.24	0.32	0.26	0.20	0.22	0.25	0.1
PI6	0.15	0.02	0.24	0.21	0.25	0.20	0.18	0.32	0.27	0.18	0.2
PI7	0.13	0.03	0.27	0.19	0.27	0.24	0.22	0.28	0.28	0.29	0.2
PI8	0.04	-0.03	0.18	0.07	0.21	0.24	0.21	0.24	0.25	0.29	0.1
PI9	0.15	0.05	0.24	0.16	0.23	0.20	0.19	0.27	0.23	0.22	0.2
PI10	0.12	0.04	0.23	0.13	0.20	0.17	0.17	0.23	0.20	0.22	0.2

Intercorrelations of Mathematics Achievement, Career Aspirations, and Perceived Importance of Mathematics continued

	Grade 11											
	Ach11	CA11	PI1	PI2	PI3	PI4	PI5	PI6	PI7	PI8	PI9	PI10
Grade 11												
Ach11	1.00											
CA11	0.34	1.00										
PI1	0.03	0.09	1.00									
PI2	0.11	0.16	0.37	1.00								
PI3	0.07	0.13	0.41	0.46	1.00							
PI4	0.08	0.10	0.39	0.16	0.42	1.00						
PI5	0.02	0.08	0.38	0.16	0.41	0.70	1.00					
PI6	0.10	0.06	0.33	0.40	0.44	0.38	0.40	1.00				
PI7	0.07	0.70	0.31	0.23	0.48	0.46	0.48	0.48	1.00			
PI8	0.06	0.02	0.36	0.16	0.43	0.51	0.54	0.41	0.64	1.00		
PI9	0.05	0.15	0.32	0.35	0.47	0.31	0.35	0.49	0.45	0.43	1.00	
PI10	0.10	0.16	0.29	0.29	0.43	0.32	0.34	0.41	0.47	0.47	0.54	1.00
Grade 12												
Ach12	0.79	0.30	0.06	0.10	0.08	0.11	0.05	0.14	0.12	-0.03	0.07	0.14
CA12	0.34	0.61	0.06	0.12	0.08	0.09	0.08	0.05	0.09	0.01	0.08	0.07
PI1	0.19	0.15	0.39	0.26	0.27	0.27	0.29	0.25	0.23	0.22	0.26	0.25
PI2	0.20	0.16	0.22	0.41	0.28	0.17	0.19	0.29	0.18	0.14	0.28	0.25
PI3	0.25	0.15	0.30	0.28	0.38	0.24	0.26	0.31	0.34	0.28	0.29	0.33
PI4	0.18	0.09	0.29	0.12	0.22	0.42	0.39	0.26	0.32	0.35	0.21	0.25
PI5	0.12	0.10	0.28	0.14	0.29	0.41	0.43	0.27	0.34	0.36	0.24	0.27
PI6	0.14	0.07	0.23	0.26	0.28	0.25	0.23	0.38	0.28	0.25	0.31	0.25
PI7	0.16	0.07	0.27	0.20	0.32	0.26	0.28	0.31	0.42	0.33	0.25	0.24
PI8	0.06	-0.01	0.25	0.15	0.28	0.31	0.34	0.24	0.36	0.38	0.21	0.25
PI9	0.15	0.10	0.25	0.26	0.28	0.27	0.27	0.26	0.29	0.25	0.35	0.29
PI10	0.12	0.06	0.22	0.21	0.29	0.23	0.25	0.25	0.34	0.30	0.30	0.41

Intercorrelations of Mathematics Achievement, Career Aspirations, and Perceived Importance of Mathematics continued

	Grade 12											
	Ach12	CA12	PI1	PI2	PI3	PI4	PI5	PI6	PI7	PI8	PI9	PI10
Grade 12												
Ach12	1.00											
CA12	0.33	1.00										
PI1	0.16	0.11	1.00									
PI2	0.22	0.19	0.41	1.00								
PI3	0.25	0.15	0.48	0.46	1.00							
PI4	0.19	0.11	0.50	0.21	0.50	1.00						
PI5	0.14	0.13	0.47	0.23	0.48	0.73	1.00					
PI6	0.16	0.04	0.44	0.48	0.53	0.43	0.44	1.00				
PI7	0.16	0.03	0.48	0.29	0.53	0.51	0.54	0.51	1.00			
PI8	0.05	-0.04	0.45	0.19	0.48	0.59	0.62	0.41	0.69	1.00		
PI9	0.14	0.10	0.42	0.37	0.50	0.38	0.44	0.53	0.48	0.47	1.00	
PI10	0.12	0.06	0.40	0.28	0.47	0.43	0.46	0.42	0.50	0.49	0.60	1.00